Public-private innovation networks and innovation activities in French service firms

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Abstract:

Using firm-level data provided by the 4th Community Innovation Survey (CIS4), this paper measures the effect of cooperation on innovation in French service firms. It distinguishes between the effects of two types of cooperation or innovation networks (INs): public-private innovation networks and private-private innovation networks. The empirical evidence presented shows that extended public-private INs (in which service firms cooperate not only with public but also with private actors) seem to be more efficient than strict public-private INs as regards product, organizational and market innovation. Private-private INs for their part seem to be more efficient in the case of process innovation.

1. Introduction

The development of innovation networks (INs) is linked to the rise of "open innovation" strategies (Chesbrough, 2003, 2010), and also to the use of complex technology, which means that firms (even the most innovative ones) are unable to meet the increasing demand for complex knowledge using solely their own internal resources. Consequently, innovative firms rely on external resources (open model of innovation) to supply their knowledge and technological competences (Hagedoorn et al., 2000; Bayona et al., 2001; Tether, 2002; Miotti and Sachwald, 2003), and to reduce the risk associated with the innovation process.

The concept of IN was mainly developed to discuss technological (traditional) INs, i.e. networks whose main objectives are to mobilize complex knowledge and technology to produce new artifacts or technological innovations mainly in the manufacturing sector (Freeman, 1987, 1995; Lundvall ed., 1992; Nelson, 1993; Edquist ed., 1997; Hall et al., 2000; Miotti and Sachwald, 2003; Faems et al., 2005).

More recently, in services, due to major economic and technological changes (globalization, convergence of consumer preferences, pervasiveness, shortening of the life-cycle of service outputs and high-skill labor intensity of many service innovations), internal connections have hampered the abilities of service organizations alone to provide the knowledge, resources and competences required to keep pace with their innovation activities. Thus, external connections through collaboration relationships and INs are likely to be a successful strategy to obtain complementary cognitive resources and enhance innovation in services. In other words, service organizations are shifting from a traditional (linear) perspective to a more system-centered approach to innovation (non-linear model of innovation). In such an approach the innovation processes are complex, systematic, multi-level, and employ a plurality of heterogeneous economic factors (Lundvall 1992, Freeman 1988; Nelson; 1993).

Compared to manufacturing, cooperation frameworks for service innovation are under-explored in the literature, perhaps due to the fact that the issue of innovation in services has long been ignored in the literature (Gallouj and Dlellal, 2010). Another reason in the traditional idea that collaboration between organizations or innovation networks involves complex knowledge and R&D activities, whereas innovation in service organizations is not supposed to be based on such knowledge and activities. Moreover, while there is considerable literature on the provision of services by public-private partnerships (PPPs), the cooperation between public and private actors to produce service innovation is still under-estimated. The limited literature about cooperation for innovation in services mainly focuses on INs between private actors only (private-private INs).

The aim of this paper is to help fill the literature gap regarding INs as an economic reality in services by also exploring the role that cooperation between public and private actors (public-private INs) can play in mobilizing new and heterogeneous cognitive resources that are essential in the production of service innovation. To achieve this goal, two types of cooperation strategies were compared. The first strategy involves service firms that cooperate solely with other private partners (e.g. consumers, suppliers and rivals) to form "private-private INs." The second strategy involves service firms that cooperate with public actors (e.g. universities and public research centers) to form "public-private INs." Public-private INs are classified into two types: 1) "strict public-private INs" which are formed when private service firms cooperate with public actors only and 2) "extended public-private INs" which are formed when private service firms cooperate with both public and private actors.

The paper is organized as follows. In the second section we discuss a certain number of key theoretical and empirical arguments concerning the relationship between innovation behavior and the strategy of cooperation for innovation by considering two cooperation strategy modes: cooperation with private actors (consumers, suppliers, competitors, etc.) and cooperation with public actors (universities, public research centers, etc.). In the third section, we analyze the cooperation strategies implemented by service firms in their innovation activities, using data from the French version of the fourth community innovation survey (CIS4). We measure the effect of cooperation of private firms with public actors on the innovation outcome, and compare it with their cooperation with private actors. In the fourth section, we summarize the results of the empirical analysis and provide appropriate recommendations.

2. Theoretical and empirical arguments for Cooperation for innovation

The aim of this section is to review the theoretical and empirical background of cooperation for innovation or INs, and its influence on firms' innovation activities. INs are the most important application of the non-linear (open) model of innovation. They can be embedded in services in different forms: INs with homogeneous actors (e.g. private actors from the same business lines or private actors from the same sector), INs with heterogeneous actors (public and private actors).

2.1 Innovation networks as a non-linear model of innovation

Rapid globalization, convergence of consumer preferences, high competition for limited scientific resources (Tushman, 2004), intensive and permanent changes in technology, spurred by great scientific advances (Aubert, 2004), have led to organizational and structural deficiencies. Local connections (linear model of innovation) in innovative organizations are generally not able to reformulate their competitive skills or provide the cognitive resources required to keep pace with new innovations. This reduces the sustainability of the innovation processes and makes it difficult to achieve innovation without having global connections (non-linear model of innovation) to exchange knowledge and information with the surrounding environment. Innovation networks are one of the most prominent expressions of the non-linear model of innovation.

The concept of INs is also foreshadowed by the evolution of open innovation (Chesbrough, 2003), in which innovation is developed by networks of actors who collaborate to produce, exchange and commercialize cognitive resources (knowledge, skills, experiences, etc). In other words, firms develop their innovation through interaction with external sources of knowledge, ideas, and technology. The open innovation model —which was developed mainly for the manufacturing sector— is expanded into a "service open innovation" model (Chesbrough, 2011) encompassing service activities. The service open innovation model focuses mainly on the role of co-creating with customers and relationality to develop sustainable business models in the service sector that lead to more value creation for customers. Recently, applications of the service open innovation model have flourished.

Examples include “NineSigma[1]” which helps their clients to create and maximize value from their innovation activities, “Idea Connection” which finds solutions for biotech and chemistry firms, and “Bright Idea” which provides social innovation management software.

2.2 Network with heterogeneous cooperation partners

Complex technologies are the main outcome of innovation networks (Rycroft and Kash, 2004). Various skills and competencies may be required in such situations that would not otherwise be available without the involvement of different partners. Each partner in the network has a specific role to play and is expected to have distinct effects on the innovation outcome (Nieto and Santamarıa, 2007). As such, finding proper partners to maximize the cooperation effect is a strategic decision for cooperative agreements (Cyert and Goodman, 1997; Doz et al., 2000; Arranz and Arroyabe, 2008). Different strategies may be used to measure the effect of the network, depending on how the network actors are classified. The effect of each actor can be measured separately, or broken down into horizontal and vertical cooperation, public and private actors.

The literature highlights the positive relationship between the partnership mode and innovation performance. Fritsch and Lukas (2001), using a sample of German manufacturing companies, found that cooperation with suppliers leads to a lower value-added to sales ratio than cooperation with other partners, because the resources gained from cooperation with suppliers replace rather than complement internal resources. Segarra-Blasco and Arauzo-Carod (2008), examining innovative Spanish firms (manufacturing and services), found a degree of complementarity between cooperation partners (for example complementarities between universities and clients).

2.2.1. “Private-Private Cooperation” strategies

The literature on private-private INs generally distinguishes between three types of private partners, each with specific characteristics (competencies,

1 www.ninesigma.com

resources and strategies, etc.) and complementary assets that drive other partners to cooperate.

The first one is the consumer —a key link in the supply chain— who provides information on needs and ideas for innovation. Cooperation with consumers is crucial in alleviating the risk of introducing complexity and novelty into the market (Von Hippel, 1988; Gardiner and Rothwell, 1985; Tether, 2002).

Suppliers are another crucial external source of information. Cooperation with suppliers is the subject of much discussion “in the context of ‘make or buy’ decisions” (Tether, 2002), which goes beyond the objective of minimizing the cost of developing new knowledge and technologies. Suppliers have a vital role to play in the innovation process throughout the supply chain (Schiele, 2006). They are an important element in dealing with the major changes associated with the innovation process, such as changes in consumer preferences and shortening product life cycles (Fossas-Olalla et al., 2010). The nature (type) of the relationship between a firm and its suppliers is determined by several factors including the level of communication, the length of the cooperation relationship, the objective of the cooperation and the degree of dependence (Fossas-Olalla et al., 2010).

Competitors (rival firms) represent the third type of private partner for innovation. As it becomes easier and faster to duplicate new products, cooperation with competitors is becoming crucial for firms in order to share the costs and risks of developing easily copied technologies. Cooperation with competitors is also discussed outside the transaction cost framework. In this perspective, Tether (2002) mentions three situations beyond the cost-saving debate: firstly, actors may cooperate in order to introduce products or services based on common standards. Secondly, cooperation may be partial, i.e. firms cooperate on some elements of the output depending on complementary weak and strong points. Finally, competitors collaborate to solve common problems that are not related to competition.

Empirically, Zeng et al. (2010), on the basis of a survey of 137 Chinese manufacturing SMEs, found that cooperation with suppliers and clients plays a more significant role in innovation than horizontal cooperation with research institutions, universities and government agencies. Veugelers (1997); Fritsch and Lukas, (2001); Arora et al., (2001) and Tether (2002) found that R&D cooperation with customers, suppliers and competitors has a positive influence. Alvarez et al. (2009), using data from the Spanish manufacturing sector, found that cooperation between competitors tends to have a greater influence on company performance compared to cooperation with other partners. In contrast, Whitely (2002), Miotti and Sachwald (2003), Nieto and Santamarıa (2007) reported that cooperation with suppliers, clients and research organizations has a positive effect on innovation, but that cooperation with competitors (rivals) has a smaller effect on innovation.

2.2.2. "Public-Private Cooperation" strategies

The need for direct public participation (cooperation) in innovation has been confirmed by numerous works (Mayntz, 1997; Messner, 1998; Morgan and Nauwelaers, 1999; Nauwelaers and Wintjes, 2003). Interactive modes of public intervention and associational forms of governance (e.g. public decisions, actions and arrangements) are likely to improve innovation performance compared to traditional public intervention (top-down policy strategies). This explains the pressure that public actors experience in developed countries to move closer to industry.

Public actors are present in several forms, including universities, public research centers, and government agencies. Each of them has particular characteristics that may be a source of specific scientific and technological knowledge (Lundvall, 1992; Nelson, 1993). For example, universities and research institutes are important entities for the creation and dissemination of scientific knowledge (Hemmert, 2004). They have a high level of research potential and diversity and play a vital role in the economic competitiveness of countries (Archibugi and Coco, 2004). Universities are also important, since the focus of interest is on original path-breaking developments, whether in science or technology (Etzkowitz, 2002). In most industries, the role of universities is important in the transfer of know-how from laboratory to industry (Dessy, 2006).

Government agencies are also important public actors. Firms cooperate with them in order to benefit from government competences (e.g. laws, legal competences, governmental roles, policy intervention tools and public administrations) and take advantage of public financial resources.

There are not many empirical works on public-private cooperation and they do not focus on services. Arranz and Fernadez de Arroyabe (2008) point out that innovative Spanish firms have a high cooperation ratio with public actors: 16% for government and 18% for universities. They found that vertical cooperation is more efficient when firms seek to overcome market and technological risks and cooperate with public partners to obtain financing mainly for the high-mid-tech sector with limited technological resources. Others found that collaboration with research institutes and universities positively affects product innovation performance (McMillan et al., 2000; Vuola and Hameri, 2006; Monjon and Waelbroeck, 2003; Faems et al., 2005). Belderbos et al. (2004) found that incoming source-specific spillovers are weaker in the case of cooperation with competitor firms, while institutional spillovers have a positive impact on all modes of cooperation. In contrast, some authors found that collaboration with universities and research institutes has a negative effect on product innovation performance (Monjon and Waelbroeck, 2003; Caloghirou et al., 2004).

2.3. The relationship between cooperation and innovation outcome

High innovation performance is generally associated with a high level of cooperation and network-based cooperation (Rycroft, 2007). Through cooperation, firms can access new knowledge, technological resources and know-how that extend their knowledge and technological capabilities, resulting in new innovation products. The positive influence of networking behavior on innovation output is confirmed by many studies (Powell, Koput and Smith-Doerr, 1996; Ahuja, 2000; Powell and Grodal, 2005; Veugelers, 1997; Calia et al., 2007; Porter and Ketels, 2003; Becker and Dietz, 2004).

The nature (type) and number of cooperative actors in the network is likely to have a crucial influence on the degree to which the cooperation effect impacts innovation outcome (Vinding, 2003 and Becker and Dietz, 2004). It is to be expected that in a network geared toward producing new complex technologies, cooperation with universities and research centers is more strategic than cooperation with actors who have low technological capabilities. On the other hand, cooperation with consultancy firms is more efficient in a network for producing new strategic or organizational solutions for clients. When more actors belong to the network, then more knowledge and technological opportunities might be available for network actors, thereby influencing their innovation capabilities and the development of new products.

Many empirical works have tried to measure the impact of different types of cooperation networks on either the performance of innovative firms or on the economy as a whole. The results are contradictory. They are positive and significant for a large number of firms, but insignificant or negative for others. For example, Brioschi et al. (2002); Becker and Dietz (2004); Nieto and Santamarıa (2007) revealed how the implementation of additional external capabilities has positively affected the realization of innovations. In Japan, Fukugawa (2006) explained how networking speeds up innovation and allows firms to access external expertise and resources. Hewitt-Dundas (2006) in a similar work showed how innovation cooperation with external actors in SMEs provides firms with the resources and capabilities that might supply them with the stimulus and capacity to innovate. In contrast, Larsson and Malmberg (1999) found no evidence for a positive relationship between technological cooperation and firm performance, in terms of the level of technology or innovative capacity. Fritsch and Franke (2004), using data from three German regions, found that cooperative relationships cannot provide the level of knowledge spillovers required for efficient innovation activities.

3. Empirical model, data and estimation method

As we mentioned earlier, we will use the data on cooperation for innovation available in the fourth community innovation survey (CIS4) in order to explore the significance of innovation cooperation for French innovative service firms, i.e. the relationship between cooperation for innovation and the introduction of four types of innovations (product, process, organizational and market innovation). We will take into account the fact that innovative firms are able to pursue different types of strategies for cooperation. For example, as regards the character of cooperation partners (public or private), firms can cooperate with public actors, private actors, or both in order to enhance their innovation output.

Before we estimate the relationship between cooperation and innovation, we will provide a descriptive view of the data set and the survey characteristics, and some descriptive statistics about the dependent and independent variables used in the model.

a. Data

CIS4 is a cross-sectional survey of all firms with over 10 employees in all 27 EU member states. In France it also concerns firms with fewer than 10 employees (micro-firms). It covers a three-year period from the beginning of 2002 to the end of 2004, with 2004 taken as the reference year for the innovation variables. The survey is based on a sample of 17,000 firms that includes all manufacturing sectors and many, but not all, service sectors. Service activities which are the main focus of our research are grouped between 50 and 74 on NACE codes ((NACE Rev. 1.1)[2] and they represent nearly 56.89% of all firms in CIS4 data.

b. Dependent variables

There is no consensus as regards the most relevant innovation performance index for measuring innovation performance (Zeng et al. 2010). It has been measured in the literature using different indicators such as the proportion of annual sales of new products (Zeng et al., 2010), the new products index (Fischer et al., 2001; Romijn and Albadalejo, 2002; Todtling et al., 2009; Zeng et al., 2010), sales of innovative products (Miotti and Sachwald, 2003; Negassi, 2004, Tsai, 2009) and the value-added to sales ratio (Fritsch and

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2 Statistical classification of economic activities in the European Community

Franke, 2004). For our purpose, we use the innovation output index where a firm's innovation output is represented by four dummy variables. Each of these variables is equal to one if the firm introduced a product, process, market or organizational innovation, respectively, between 2002-2004. Non-technological (market and organizational) innovation types that are important in services are taken into account.

Table 1 shows the percentage of firms introducing different types of technological and non-technological innovations in service firms. They introduce all types of innovation activities with the highest score for organizational innovation (nearly 40%). This is consistent with the fact that non-technological activities (disembodied artifacts) are the most important innovation activities in services.

Table 1: Percentage of service firms introducing different types of innovations

Innovation activity	**Percentage**
Firms implementing one or more innovation mode(s)	54
Product innovation	20
Process innovation	29
Organizational innovation	40
Market innovation	27

c. Independent variables

Our goal is to measure the effect of cooperation on innovation output. Cooperation for innovation will therefore be our core independent variable. Cooperation is performed either between private actors forming "private-private INs" or between public and private actors forming "public-private INs." In private-private INs, innovative service firms cooperate with one or more of the following agents: other enterprises in their enterprise group, suppliers (equipment, materials, components or software), clients, competitors or other enterprises in their sector, and consultants, commercial labs, or private R&D institutes. Public-private INs can be split into two modes. In “strict public-private INs,” a private service firm cooperates with one or more public actors (universities or other higher education institutions and public organizations involved in R&D or private not-for-profit research institutes). “Extended public-private INs” are networks where the private innovative service firm cooperates with one or more private actors as well as one or more public actors. This extended public-private IN allows private firms to access not only the knowledge and technologies of public actors but also that of other private actors, where additional complementary resources are available and more innovation activities are feasible.

The fact that public actors in CIS4 are only represented by universities or other higher education institutions and public organizations involved in R&D or private not-for-profit research institutes is one of the limitations of this study. These public actors are mainly involved in producing complex and technological knowledge. The survey doesn’t cover other public services that could be sources of other types of knowledge and competences.

Table 2 shows the percentage of firms cooperating for innovation by type of partner in French service firms. It shows that 29.67% of firms implement all types of innovation cooperation in services. Private cooperation is more prevalent than public cooperation: only 1% of firms cooperate solely with public actors compared to 19.4% with private actors alone and 7.97% with both public and private actors (extended public-private INs).

Table 2: Percentage of firms cooperating for innovation by type of partners

Cooperation mode	**Percentage of firms in service sectors**
Not cooperate at all	70.33
Cooperate with any actors	29.67
Enterprise in your enterprise group (a)	45.03
Supplier of equipment, materials, components or software (b)	57.85
Clients or customers (c)	44.03
Competitor or other enterprise in your sector (d)	35.47
Competitor in other group (e)	_____
Consultants, commercial labs, or private R&D institutes (f)	29.05

Universities or other higher education institutions only (g)	23.81
Public R&D organization or private not-for- profit research institutes (h)	20.83
Cooperation with private actors only (a or b or c or d or e or f)	19.4
Cooperation with public actors only (h or g)	1
Cooperate with both public and private actors (a or b or c or d or e or f) and (h or g)	7.97
Number of observations	6076

In addition to innovation cooperation variables, the model includes a certain number of control variables: firm size, service subsectors and government subsidies (see Table 3). Firm size is one of the key control variables, to the extent that innovation output may vary according to size. For example, innovation activities other than R&D (which are supposed to be the main innovation activities in services) are widely performed by small and medium sized units (see table 4). Large-sized firms are supposed to have more opportunities to benefit from economies of scale in both production and innovation (mainly R&D) (Cohen, 1996), therefore size is expected to have a positive effect on innovation activities. Most empirical studies reveal the positive effect of firm size. However, in some cases small firms might be more innovative than larger ones. In terms of cooperation, Fritsch and Lukas (2001) found that large firms are more likely to engage in cooperation (R&D cooperation). In contrast, Negassi (2004), in discussing the determinant of R&D cooperation, saw no significant difference between firms with small and large market shares with regards to cooperation. In this study, firm size is measured on the basis of the number of employees, as follows: “small firms” (from 10 to 49 employees)[3], “medium firms” (from 50 to 250 employees), and “large firms” (more than 250 employees).

Table 3: Descriptive analysis of control variables

Independent variable	**Percentage (%)**

3 Micro firms with fewer than 10 employees were dropped from the analysis.

Firm size	
Small firm 10 ≤ employees < 50	41.06
Medium firms 50 ≤ employees < 250	32.49
Large firms 250 ≤ employees	26.45
Public subsidy for innovation activities	
Local or regional authorities	6.59
Central government (including central government agencies or ministries)	12.13
The European Union (EU)	5.94
Tax credits (including research tax credit)	10.28
Sectoral patterns	
Sale, retail, maintenance	5.46
Other wholesale trade	16.66
Other retail trade	10.16
Hotels & restaurants	4.97
Land transport	7.14
Water transport	0.48
Air transport	0.24
Supporting and auxiliary transport activities	4.90
Post and telecommunications	1.48
Financial intermediation	7.52
Real estate and renting	5.34
Computer and related activities	6.07
R&D	3.39
Other business activities	24.24
Other community, social and personal service activities	1.93

Table 4 shows that small service firms are more innovative than large and medium firms. If we look at the percentage of innovative firms in terms of firm size, we observe that small, medium and large firms realize similar proportions of product and process innovation, whereas small firms introduce more organizational and market innovation than large and medium firms.

Table 4: Innovative firms in the service sector by firm size

Employee category	**Service firms (2002-2004)**				
	Innovation Output	**Product innovation**	**Process innovation**	**Organizational innovation**	**Market innovation**
10-49	21.2	6.7	9.8	15.4	9.9
50-249	16.8	6.2	9.6	12.4	8.1
> **250**	13.7	6.5	9	10.5	8.4

We include sectoral differences as another control variable. We build our study on the existence of sectoral differences between service industries regarding the amount of resources devoted to innovation (Evangelista and Savona, 2003), and the amount of innovation produced. For example, in France, there is heterogeneity between service subsectors regarding the intensity of R&D activities devoted to innovation (see table 5). Service activities like R&D, information technology, post and telecommunication perform high intramural R&D activities, but subsectors like sale, retail, maintenance and other retail trade (12.16%) perform low intramural R&D activities. Also, heterogeneity was noticeable between service subsectors regarding extramural R&D (but less than for intramural R&D), for example 53% of R&D firms implement extramural R&D whereas only 3.44% of sale, retail and maintenance firms do.

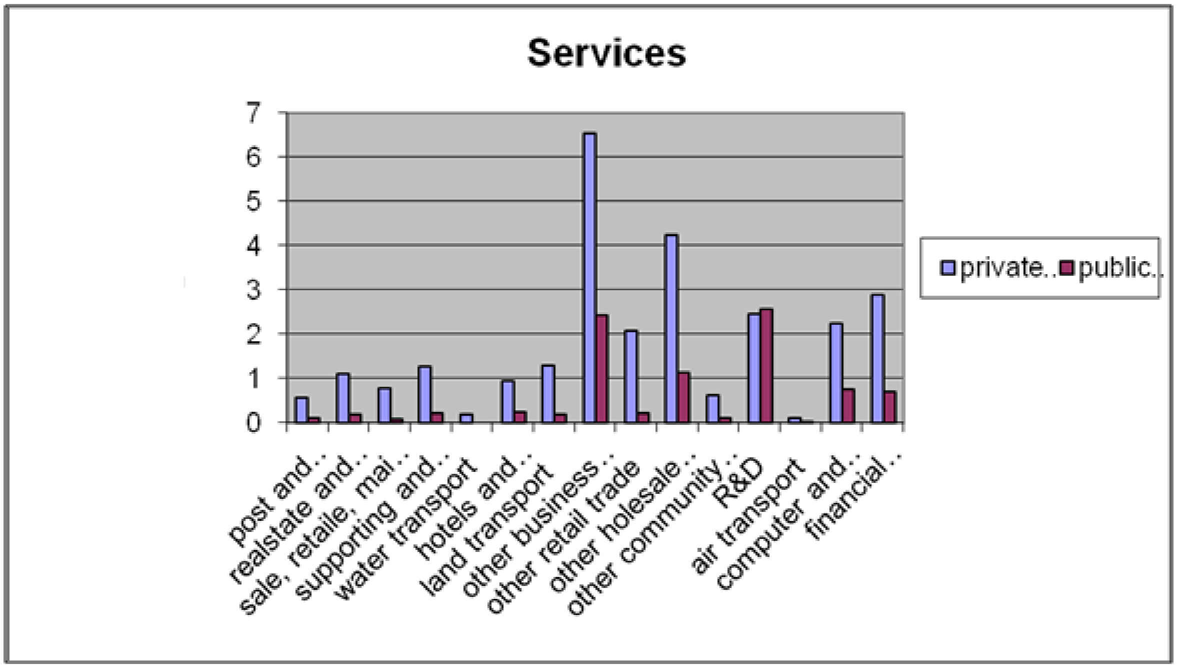
There is also heterogeneity between French service subsectors in relation to their size (number of firms). Table 3 shows that other business services (24.24%) and other wholesale trade (16.66%) are the biggest sectors, while air transport and water transport are the smallest ones with 0.24% and 0.48% of the total number of firms respectively.

Table 5: Percentage of service subsectors that perform internal and external R&D

Service subsector	Intramural (in house) R&D (%)	Extramural R&D (%)
Sale, retail, maintenance	8.98	3.44
Other wholesale trade	22.55	9.86
Other retail trade	12.16	5.49
Hotels & restaurants	13.06	4.76
Land transport	13.40	6.01
Water transport	18.87	11.32
Air transport	29.17	4.17
Supporting and auxiliary transport activities	23.24	11.13
Post and telecommunications	42.22	12.59
Financial intermediation	37.56	11.60
Real estate and renting	18.20	5.90
Computer and related activities	53.18	11.95
R&D	78.28	53.56
Other business activities	12.16	8.43
Other community, social and personal service activities	26.07	6.41

In terms of IN trends, figure 1 shows the disparity between service subsectors in terms of the percentage of cooperation for innovation with public or private actors. In private cooperation, the cooperation percentage varies from 0.1% in air transport to 6.55% in other business activities. Public cooperation varies from 0% in water transport to 2.57% in the R&D subsector. Thus, cooperation with private actors is higher than cooperation with public actors for most service subsectors. The R&D subsector highly cooperates with public actors because public actors like universities and research centers are a major source of R&D.

Figure 1: Percentage of cooperation for innovation with public and private actors in different service subsectors in 2004



Public financial support (subsidies) for innovation is the last control variable. It is mainly provided by local and regional authorities, and central governments (national government and EU institutions). Public financial support is not the same as public cooperation. In public cooperation, public actors get involved in networks as main partners who share knowledge, technologies, and financial resources with private actors and provide them with government competences. As regards public subsidy, private actors organize, monitor and control the innovation process, and these public actors are not involved directly in the project. They merely provide financial support without being involved in the exchange and creation of knowledge. We will compare these two modes of public action in order to assess which one is the most efficient to enhance innovation.

Table 3 shows that the central government is the main supporter for innovation activities in services (12.13%) compared with local or regional authorities (6.59%) and the European Union (5.94%). This is due to the governance system in France, which grants the central government the main role in public policy. At 10.28%, tax credits (including research tax credit) are also an important public policy for supporting innovation activities.

4. Discussion of the results of the empirical analysis

In this section we present and discuss the results of our empirical investigation, i.e. the effect of cooperation on innovation output in French service industries. The estimation strategy is a compound of two models. In model 1, we estimate the effect of cooperation on the four types of innovation output (product, process, organizational and market innovation). The result of model 1 may be used as a reference point for the other cooperation tests. In model 2, we measure the innovation effects of cooperation for three different types of innovation networks: private cooperation (Private-Private INs), public cooperation (Strict public-private INs), and cooperation with both public and private actors (Extended public-private INs).

The model used to estimate our relationship is the binary choice Logit model. It is run separately for every dependent variable (product, process, organizational and marketing). The alternative "innovate or not" is made possible for every dependent variable.

4.1 The effect of INs in services

Table 6 presents the results of cooperation for innovation regardless of partner types. The results do strongly support the positive impact of INs on innovation output, for all types of innovation (product, process, organizational and marketing innovation), i.e. the more cooperation, the more likely a firm is to introduce more innovation output. Although market and organizational innovation are more frequent than product innovation (see table 1), cooperation is more efficient for both product and process innovations (technological innovations). This can be explained by the fact that product and process innovations are technological innovations, which are based on complex scientific and technological knowledge and skills not always available within the firm and only found elsewhere. Conversely, market and organizational knowledge is more specific to the firm and idiosyncratic, which may reduce the need for external cooperation.

Table 6: Logit Estimation for the impact of cooperation on the likelihood of introducing innovations.

	Product innovation		Process innovation		Organizational innovation		Market innovation	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > Chi Sq
Intercept	0.5298	0.0041	0.1574	0.2983	1.1185	<.0001	-0.0583	0.6428
Cooperation								
Cooperation	1.5838	<.0001	1.8456	<.0001	0.3038	<.0001	0.4566	<.0001
Observation number	6076		6076		6076		6076	
Wald test	1144.4035		815.9124		100.1122		290.2511	
Percentage concordant	78.4		71.6		56.0		60.8	

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

As regards the control variables, firm size (SIZE1) has a strong and positive significant effect on the level of innovation output for all types of innovation output (product, process, organizational and market innovation). In other words the relationship between innovation output and firm size is robust and consistent (see table 7). Innovative large firms have a higher effect on innovation output than medium and small firms. This means that large firms perform better than medium and small firms in all modes of innovation. However, in the case of market innovation, medium firms appear to have less effect compared with small ones. This result is consistent with what was mentioned earlier, that is, firm size is expected to have a positive effect on innovation activities.

Table 7: Differences in innovation activities according to firm size

Size (ref = 10 ≤ employees<50)	**Product innovation**		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > Chi Sq	Estimate	Pr > Chi Sq	Estimate	Pr > Chi Sq	Estimate	Pr > ChiS q

50 ≤employees<250	-0.0570	0.1958	0.0559	0.1696	-0.0434	0.3127	-0.1308***	0.0006
250 ≤ employees	0.3100***	<.0001	0.3018***	<.0001	0.0908*	0.0556	0.3240***	<.0001

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

Table 8 shows significant differences between service subsectors as regards the level of innovation output, whatever the type of innovation considered: product (ChiSq=272.22, P-value<0.0001), process (ChiSq=32.11, P-value=0.0039), organizational (ChiSq=56.6, P-value<0.0001) and market innovation (ChiSq=125.6, P-value<0.0001). The heterogeneity between service subsectors is higher for product and market innovation.

Different groups of service subsectors can be distinguished according to the heterogeneity in the amount of innovation produced. For example, as regards product innovation, three main groups are identified. The first includes other retail trade, air transport, hotels, restaurant and financial intermediation, which perform product innovation more than in the R&D sector. The second includes real estate and renting, post and telecommunication, supporting and auxiliary transport activities and water transport with less product innovation than in the R&D sector. The third group includes other wholesale trade, sale, retail, maintenance, land transport, other business activities and other community, social service activities with as much product innovation as in the R&D sector. As regards organizational innovation, two main groups can be identified. The first comprises sale, retail and maintenance, supporting and auxiliary transport activities and post and telecommunication with less organizational innovation than in R&D services. The second includes other service subsectors, which have as much organizational innovation as in the R&D services.

Table 8: Differences of innovation activities in relevant service subsectors

Subsector (ref = R&D)	Product innovation		Process innovation		Organizational innovation		Market innovation	
Parameter	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq	Estimate	Pr > ChiSq
Sale, retail, maintenance	0.1797	0.3775	0.3660*	0.0633	-0.7614***	<.0001	0.1017	0.5718
Other whole sale trade	-0.4847	0.4039	-0.0626	0.9130	1.3027	0.1790	0.9586	0.1191
Other retail trade	1.2620***	<.0001	0.1418	0.2530	0.1359	0.3413	-0.1117	0.3273
Hotel s& restaurants	0.6518***	<.0001	0.1792	0.1296	0.1798	0.1978	0.3995***	0.0004
Land transport	-0.1683	0.2396	-0.0837	0.5213	-0.1595	0.2786	0.4115***	0.0012
Water transport	-0.2610**	0.0384	-0.1939*	0.0898	0.0921	0.4978	-0.7485***	<.0001
Air transport	0.2051**	0.0137	0.0436	0.5870	0.00111	0.9912	-0.2414***	0.0017
Supporting and auxiliary transport activities	-0.8724***	<.0001	0.0649	0.5203	-0.5048***	<.0001	0.1447	0.1373
Post and telecommunications	-0.2451***	0.0091	0.0168	0.8485	-0.2046*	0.0524	0.1782**	0.0343
Financial intermediation	0.7312***	0.0021	-0.1370	0.5528	-0.2934	0.2041	0.1437	0.4931
Real estate and renting	-0.2873**	0.0420	-0.1737	0.1748	0.2307	0.1345	0.1854	0.1284
Computer and related activities	-0.8094***	<.0001	-0.2451*	0.0534	0.1563	0.2992	0.2406**	0.0473
Other business activities	0.0718	0.6039	0.4084***	0.0026	-0.0256	0.8662	-0.4970***	<.0001
Other community, social service activities	0.0505	0.9012	0.2062	0.6194	0.0988	0.8214	-0.4755	0.1940

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

4.2. Cooperation impact according to types of innovation networks

Table 9 shows that public-private INs and private-private INs are both efficient strategies to produce innovation in services. This result shows that the non-linear (open) model of innovation constitutes a sustainable way to access the external knowledge and technological resources needed to produce innovation in services. It confirms the importance for service firms to shift from a linear to a non-linear model of innovation in which innovation is provided through complementarity between skills, competences, knowledge and technologies of more than one partner. It also demonstrates the synergies that public and private actors can mobilize through collaboration to produce innovation in services.

Both private-private INs and public-private INs are more efficient in producing technological innovation (product and process innovation) than non-technological innovation (organizational and market innovation). This is consistent with the result put forward in section 4.1 that cooperation for innovation is more efficient to produce technological innovation, because, as we said, market and organizational knowledge is more specific to the firm and idiosyncratic, which may reduce the need for or the scope of external cooperation. Furthermore, public actors in public-private INs are mainly represented by universities and public research centers that are major sources of complex knowledge primarily used to produce technological innovation.

Table 9 also shows that in the case of product and process innovation, cooperation with public actors either through extended public-private INs or strict public-private INs has a positive and significant impact on innovation output. This result demonstrates the importance of public-private cooperation in mobilizing the cognitive resources needed to produce product innovation and supports the policies implemented by different OECD countries (OECD, 2005)[4], in order to strengthen links between science and service industries.

Extended public-private Ins have a more significant effect on product innovation than private-private INs, despite the high percentage of firms that participate in private-private INs (19.4%) compared with extended public-private INs (7.97%). Through extended public-private INs, firms are able to access a wide range of complementary cognitive, technological, financial,

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4 This report mentions several successful examples of cooperation between service firms and public science actors (research centers and universities), for example, in New Zealand and in the Czech Republic.

methodological and institutional resources. Private-private INs face some difficulties in providing the complex technological competences needed mainly for producing new product innovation in the services sector. Universities, research centers and R&D institutions are likely to be vital in providing such types of technological competences. This result contradicts the idea that a weak relationship exists between service firms and the public sector (OECD, 2005), and that the public sector is the least important source of information for innovation with service firms (Sundbo and Gallouj, 1998).

Private-private INs appear to be more efficient than public-private INs for achieving process innovation. Through cooperation with private partners only (e.g. other enterprises and rival firms), firms are more likely to access relevant competencies and technologies required for improving production processes, new distribution methods and support activities.

Table 9 shows that service firms also cooperate to access less complex, non S-T knowledge (organizational and market innovations). This contradicts the idea that a network-based analysis is assigned mainly to obtain new technological innovations (Edquist, 1997). Cooperation in private-private INs or extended public-private INs is important for achieving both organizational and market innovation.

Table 9: Logit model for private and public cooperation in service firms

	Product innovation		Process innovation		Organizational innovation		Market innovation	
Parameter	Estimate	Pr > chisq	Estimate	Pr > chisq	Estimate	Pr > chisq	Estimate	Pr > chi sq
Intercept	0.4804	0.0111	0.3285	0.0332	1.0371	<.0001	-0.1259	0.3399
Cooperation								
Privatecoop_o	1.5400***	<.0001	2.0401***	<.0001	0.2518***	0.0016	0.4250***	<.0001
Publiccoop_o	1.1241***	0.0004	1.1909***	0.0001	-0.1269	0.6605	-0.3088	0.2888
Mixtecoop	1.8554***	<.0001	1.3374***	<.0001	0.5923***	<.0001	0.6961***	<.0001

Observation number	6076	6076	6076	6076
Wald	1138.3107	815.9045	107.2148	300.2394
Percentage concordant	78.4	71.4	56.1	61.1

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

Extended public-private INs show the most significant effect of cooperation on both organizational and market innovation. Although they relate to non-technological innovation, organizational and market innovation may be heavily reliant on technologies (computing and telecommunication technologies), which means a need for R&D-based, complex and diverse knowledge that universities and public and private research centers provide.

4.3 Public cooperation and public subsidy

Public subsidies from local, regional or national organizations and tax credits have a positive significant effect on both product and process innovation (see table 10). In contrast, public subsidies have no effect on market innovation and a negative effect on organizational innovation. This could mean that governments more rarely subsidize firms' innovative activities related to the structure and management of the organization and sales methods.

A comparison between tables 9 and 10 shows that the direct involvement of public actors as key partners who cooperate with other private actors forming public-private innovation networks is more efficient than public subsidies (indirect involvement in innovation processes) in terms of innovation output. In other words, cooperation with public actors through the strict and extended public-private INs is more efficient for product, process, organizational and market innovation than public subsidies. Governments, through direct cooperation, can provide their own specific knowledge, and control the process of information and technology flow between different actors more efficiently. More generally they can ensure that public technological and financial capabilities are correctly used in the development of the innovation.

Table 10: The effect of public subsidy on the probability of innovation output

Public subsidy	**Product innovation**		**Process innovation**		**Organizational innovation**		**Market innovation**	
Parameter	Estimate	Pr > Chi Sq	Estimate	Pr > C hiSq	Estimate	Pr > C hiSq	Estimate	Pr > C hiSq
FunLoc	0.2658***	0.0075	0.3694***	0.0002	0.1819**	0.0490	0.1131	0.1473
FunGmt	0.4432***	<.0001	0.1416*	0.0544	-0.1507**	0.0298	-0.1709***	0.0069
FunEU	-0.1353	0.3237	0.2026	0.1964	0.0206	0.8783	0.0441	0.6997
FunRtd	0.2339	0.2365	-0.3307*	0.0792	-0.00033	0.9984	-0.1651	0.2455
CIR	0.8405***	<.0001	0.1951***	0.0056	-0.1036	0.1198	0.0368	0.5406

*Significant at 0.10 level
**Significant at 0.05 level
***Significant at 0.01 level

Conclusion

This paper highlights the effect of INs on innovation performance in French innovative service firms, considering different types of cooperation strategies. Service firms can cooperate solely with private actors to form private-private INs, solely with public actors to form strict public-private INs or with both public and private actors to form extended public-private INs.

Innovation networking and cooperation is not only important for manufacturing firms involved in high tech activities and intensive R&D cooperation. It is also important for service firms that cooperate to enhance both technological and non-technological innovation.

Our analysis shows that all types of innovation are positively affected by cooperation (one or more of the three innovation networks). However, the different innovation types are not equally affected by private-private INs and public-private INs. In other words, the efficiency of cooperation strategies may vary according to the type of innovation output. For example, extended public-private INs appear to be more efficient for product innovation, and private-private INs seem to be the most efficient strategy for process innovation.

Finally, as regards public policies to support innovation, our analysis shows that the direct involvement of public actors in public-private INs is more efficient than public subsidies (indirect involvement in the innovation process). Accordingly, public-private INs can be considered as important tools of public policy.

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